

## **Biological Based Risk Assessment for Space Exploration**

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### **Abstract:**

Exposures from galactic cosmic rays (GCR) — made up of high-energy protons and high-energy and charge (HZE) nuclei, and solar particle events (SPEs) — comprised largely of low- to medium-energy protons are the primary health concern for astronauts for long-term space missions. Experimental studies have shown that HZE nuclei produce both qualitative and quantitative differences in biological effects compared to terrestrial radiation, making risk assessments for cancer and degenerative risks, such as central nervous system effects and heart disease, highly uncertain. The goal for space radiation protection at NASA is to be able to reduce the uncertainties in risk assessments for Mars exploration to be small enough to ensure acceptable levels of risks are not exceeded and to adequately assess the efficacy of mitigation measures such as shielding or biological countermeasures. We review the recent BEIR VII and UNSCEAR-2006 models of cancer risks and their uncertainties. These models are shown to have an inherent 2-fold uncertainty as defined by ratio of the 95% percent confidence level to the mean projection, even before radiation quality is considered. In order to overcome the uncertainties in these models, new approaches to risk assessment are warranted. We consider new computational biology approaches to modeling cancer risks. A basic program of research that includes stochastic descriptions of the physics and chemistry of radiation tracks and biochemistry of metabolic pathways, to emerging biological understanding of cellular and tissue modifications leading to cancer is described.